CLAIMS

Claims 1-56 (Cancelled)

57. Apparatus for adjusting the dimensions of a tube by rolling comprising:

a plurality of cylindrical rollers, each roller comprising a first end and a second end;

a supporting cylinder comprising a first end flange and a second end flange, at least one of the end flanges being rotationally displaceable in the supporting cylinder;

the first end flange and second end flange defining a plurality of support apertures, the ends of the cylindrical rollers supported in the support apertures;

the first ends of the rollers positioned on a pitch circle and the second ends of the rollers positioned on a pitch circle of equal diameter, so that the plurality of rollers form a parallel-cylindrical array;

the first end flange defining a first tube-pass aperture and the second end flange defining a second tube-pass aperture, so that the first and second tube-pass apertures permit the tube to advance through the parallel-cylindrical array of rollers;

a means for adjusting the position of at least one of the end flanges of the supporting cylinder, so that the parallel-cylindrical array is skewed; and

a means for rotating the supporting cylinder, so that the rollers apply force to the external surface of the tube.

58. The apparatus of claim 57 wherein the rollers comprise a substantially centrally-located convex portion.

59. The apparatus of claim 57 wherein the rollers comprise a substantially centrally-located concave portion.

60. The apparatus of claim 57 wherein the diameter of the rollers is approximately 20% of the diameter of the tube.

61. The apparatus of claim 57 wherein the diameter of the rollers are with a range of 10 % to 40% of the diameter of the tube.

62. The apparatus of claim 57 wherein the supporting cylinder comprises an index mark and the rotationally displaceable flanges comprise a complementary calibration mark to facilitate adjusting the skew of the parallel cylindrical array.

63. The apparatus of claim 57 wherein the apparatus further comprises a plurality of bearings positioned in the support apertures.

64. The apparatus of claim 63 wherein the roller further comprises a first shaft positioned at on the first end of the roller and a second shaft positioned at the second end of the roller,

the shafts supported in the bearings positioned in the support apertures, wherein the length of the shafts accommodate the axial displacement caused by the skewing of the rollers.

65. The apparatus of claim 57 wherein the apparatus further comprises a plurality of yokes, the rollers rotationally supported in the yokes, each yoke pivotally mounted on a yoke support shaft, the support shaft passing radially outward through a yoke bearing provided in the supporting cylinder, the yoke comprising a plurality of skewing rings pivotally attached to the yoke, so that the yoke is skewed by applying force through the skew rings.

66. The apparatus of claim 65 wherein the yoke support shafts are threaded to engage a plurality of ball nuts, the ball nuts driven by one or more stepper motors to

radially displace the yokes.

67. The apparatus of claim 57 comprising a supporting cylinder bearing to rotationally support the supporting cylinder.

68. The apparatus of claim 67 wherein the supporting cylinder bearing is situated as closely as possible to a plane passing through the points of contact of the tube and the rollers.

69. The apparatus of claim 67 wherein the apparatus further comprises:

a radial web fixed to the supporting cylinder comprising an external surface;

a supporting cylinder bearing housing, the supporting cylinder bearing accommodated within the supporting cylinder bearing housing; and

a radial mounting flange comprising a cylindrical extension,

the cylindrical extension and the external surface of the radial web forming the supporting cylinder bearing housing.

70. The apparatus of claim 69 wherein the cylindrical extension of the mounting flange is selected from a group consisting of a pulley, a sprocket, a driving chain, and combinations thereof.

71. The apparatus of claim 57 wherein the apparatus further comprises a means for supporting the apparatus above the ground.

72. The apparatus of claim 71 wherein the apparatus further comprises a means for adjusting the height of the means for supporting the apparatus above the ground.

73. The apparatus of claim 72 wherein the means for adjusting the height of the

means for supporting the apparatus above the ground is selected from a group consisting essentially of manually-operated screw jacks, motor-driven jacks, and combinations thereof.

74. The apparatus of claim 74 wherein the motor of the motor-driven jack is a stepper motor and the apparatus further comprises a means for detecting the straightness of the tube and a means for controlling the stepper motor in response to the straightness of the tube.

75. The apparatus of claim 71 wherein the means for supporting the apparatus above the ground is attached to the supporting cylinder by a quick-release attachment.

76. The apparatus of claim 71 wherein the means for supporting the apparatus above the ground comprises a slideable frame positioned on a fixed frame.

77. The apparatus of claim 76 wherein the apparatus further comprises a means for sensing the movement of the slideable frame and a means for regulating the speed of the means for rotating the supporting cylinder.

78. The apparatus of claim 77 wherein the means for rotating the supporting cylinder is an air motor and the means for regulating the speed of the means for rotating the supporting cylinder is a pneumatic valve actuated by the movement of the slideable frame.

79. The apparatus of claim 71 wherein the means for supporting the apparatus above the ground is a fixed frame comprising one or more vertically arranged rails and one or more linear bearings positioned on the rails, the linear bearings supporting the supporting cylinder.

80. The apparatus of claim 79 wherein the means for adjusting the height of the means for supporting the apparatus is a ball screw and nut jack driven by a stepper motor and the apparatus further comprises a means for controlling the stepper motor, so that the axis of the parallel-cylindrical array of rollers is collinear with the axis of the tube.

81. The apparatus of claim 57 wherein the apparatus further comprises a means for controlling the speed of rotation of the rollers.

82. The apparatus of claim 57 wherein the apparatus further comprises a means for controlling the skew of the rollers.

83. The apparatus of claim 57 wherein the apparatus further comprises at least one sensor for detecting one or a combination of: the linear speed of the tube, the straightness of the tube, the speed of rotation of the supporting cylinder and the finished diameter of the tube.

84. The apparatus of claim 83 wherein the sensor comprises at least one pair of opposed wheels attached to linear transducers, the wheel urged into contact with the tube by a spring, so that sensor measures the finished diameter of the tube.

85. The apparatus of claim 83 wherein the sensor comprises a laser micrometer.

86. The apparatus of claim 83 wherein the sensor comprises at least one pair of opposed proximity sensors, so that the sensor measures the finished diameter of the tube by measuring the distance between the proximity sensor and the tube.

87. The apparatus of claim 57 wherein the apparatus further comprises one or more additional parallel-cylindrical arrays of rollers.

88. The apparatus of claim 87 wherein the two or more parallel-cylindrical arrays rotate in opposite directions.

89. The apparatus of claim 57 wherein the apparatus further comprises a drive belt connecting the means for rotating the supporting cylinder to the supporting cylinder.

90. The apparatus of claim 57 wherein the means for rotating the supporting cylinder is selected from a group consisting of a hydraulic motor, an air motor, an electric motor, and combinations thereof.

91. The apparatus of claim 57 wherein the path of movement of the rollers comprises a helical path.

92. The apparatus of claim 57 wherein the means for adjusting the position of at least one of the end flanges comprises a one or more adjustable length struts.

93. The apparatus of claim 92 wherein the adjustable length strut comprises a first strut end and a second strut end, the first strut end pivotally attached to the first end flange, the second strut end pivotally attached to the supporting cylinder.

94. The apparatus of claim 92 wherein the length of the adjustable length strut is adjusted by loosening a locknut.

95. The apparatus of claim 92 wherein the length of the adjustable length strut is adjusted by a motor.

96. The apparatus of claim 57 wherein the apparatus further comprises slip-rings to transmit control signals to the means for rotating the supporting cylinder

97. The apparatus of claim 57 wherein control signals are wirelessly transmitted to the means for rotating the supporting cylinder.

98. Apparatus for adjusting the dimensions of a tube by rolling comprising:

a plurality of cylindrical rollers, each roller comprising a first end and a second end;

a supporting cylinder comprising a first end flange and a second end flange, at least one of the end flanges being rotationally displaceable in the supporting cylinder;

the first end flange and second end flange defining a plurality of support apertures, the ends of the rollers supported in the support apertures;

the first ends of the rollers positioned on a pitch circle and the second ends of the rollers positioned on a pitch circle of equal diameter, so that the plurality of rollers form a parallel-cylindrical array;

the first end flange defining a first tube-pass aperture and the second end flange defining a second tube-pass aperture, so that the first and second tube-pass apertures permit the tube to advance through the parallel-cylindrical array of rollers;

a means for adjusting the position of at least one of the end flanges of the supporting cylinder, so that the parallel-cylindrical array is skewed; and

a motor to rotate the supporting cylinder, so that the rollers apply force to the external surface of the tube;

a mounting flange comprising a mounting flange bearing, the mounting flange bearing holding the supporting cylinder; and

the mounting flange and motor are attached to a moving frame.

99. The apparatus of claim 98 wherein the apparatus further comprises a means for

controlling the speed of the motor in response to the movement of the moving frame.

100. The apparatus of claim 99 wherein the means for controlling the speed of the motor in response to the movement of the moving frame is a pneumatic control system comprising:

an air line providing power to the motor; and

a valve controlling the amount of air supplied to the air line, valve comprising a link to the moving frame,

so that when the moving frame changes positioned the valve is actuated to change the amount of air supplied to the motor through the air line.

101. The apparatus of claim 99 wherein the means for controlling the speed of the motor in response to the movement of the moving frame is an electrical control system which changes the amount of electricity sent to the motor when the moving frame changes position.

102. Apparatus for adjusting the dimensions of a tube by rolling comprising:

a rotable supporting cylinder;

a plurality of cylindrical rollers in a parallel-cylindrical array within the supporting cylinder; and

a means for skewing the rollers in the parallel-cylindrical array.

103. A method for adjusting the dimension of tube comprising:

(a) passing the tube in continuous advance through a plurality of cylindrical rollers arranged in a parallel- cylindrical array in a supporting cylinder;

(b) skewing the rollers to bring the rollers the into forceful contact with the external surface of the tube;

(c) rotating the parallel-cylindrical array of rollers at a controlled speed; and

(d) controlling the degree of skewing of the rollers.

104. The method of claim 103 wherein the method further comprises the step of:
sensing the linear speed of the tube; and
controlling the speed of rotation of the rollers in relation to the linear speed of the tube.

105. The method of claim 104 wherein the speed of rotation of the rollers in manually controlled.

106. The method of claim 104 wherein the speed of the rollers is automatically controlled.

107. The method of claim 103 wherein the method further comprises the steps of:
sensing the straightness of the tube; and
controlling the height of a means for supporting the apparatus to straighten the tube.

108. The method of claim 110 wherein the height of a means for supporting the apparatus in manually controlled.

109. The method of claim 110 wherein the height of a means for supporting the apparatus is automatically controlled.

110. The method of claim 103 wherein the method further comprises the step of controlling the speed of rotation of the rollers in response to the linear speed of the tube and degree of skewing of the rollers.

111. The method of claim 103 wherein the rollers describe continuous, parallel,

overlapping, helical paths along the external surface of the pipe or tube and locally apply a compressive force to the external surface of the tube in excess of the yield stress of its material, thereby causing the tube to set at a smaller diameter.

112. The method of claim 103 wherein the passage of the rollers over the outer surface of the tube corrects any out-of-roundness of the tube and causes its external surface to be burnished.

113. The method of claim 103 wherein the method further comprises the steps of:
sensing the speed of rotation of the rollers;
sensing the height of the supporting means; and
sensing the degree of skewing of the rollers.

114. The method of claim 103 wherein the method further comprises the steps of:
passing the tube through a plurality parallel-cylindrical arrays of rollers,
the rollers contained within in a supporting cylinder; and
rotating the arrays in alternating directions.

115. The method of claim 103 wherein the method is repeated, so that each pass of the tube through the array further reduces the diameter of the tube.

116. The method of claim 103 wherein the method does not include the step of lubricating the tube.

117. The method of claim 103 wherein the method is incorporated into a tube forming mill to provide an immediate post-fabrication treatment of the tube.